Reptile Geriatrics

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KEYWORDS

• Reptile • Geriatric • Age estimation • Sensescence

The class Reptilia, a diverse assemblage of ectothermic scaled vertebrates, is classically subdivided into 4 taxonomical orders: Rhynchocephalia (tuataras), Crocodylia (crocodiles, alligators, and caimans), Chelonia (tortoises and turtles), and Squamata (lizards and snakes).[1,2] Phylogeny among these orders remains the subject of debate, but it is generally accepted that the class Reptilia is paraphyletic, so that crocodilians, for example, are evolutionarily more closely related to birds than they are to chelonians.[1,2] Substantial differences in life history, anatomy, and physiology are more likely to exist among the paraphyletic reptiles than the monophyletic mammals and birds. Striking differences in life strategies and demographics among extant reptiles do not allow for generalizations about senescence and age-related changes across orders, or even within reptilian suborders and families.

Geriatrics has long been recognized as a bona fide branch of human medicine, but only recently was it given focused veterinary attention, albeit limited to traditional companion animals. This has not yet been the case with reptiles, and although chapters devoted to perinatology are found in classic reptile medicine textbooks,[3–5] there are none specifically addressing geriatrics, the other end of the age spectrum. This article is an initial attempt to fill this void, but because solid data on ageing and senescence in reptiles are lagging behind that accumulated for other vertebrate taxa, what follows is meant more as a framework for expansion as more information becomes available. This article first addresses ageing and senescence in reptiles, then reviews available age estimation techniques for them. A summary of the known longevity data for the common captive and pet reptile species is provided. A rational approach to monitor ageing in reptile patients is proposed, and currently recognized geriatric issues and diseases are briefly listed systematically for each order and suborder of reptile.

SENESCENCE IN REPTILES

There is no simple and obvious answer to the question of when a reptile is old. Old age is a function of longevity or expected lifespan of a particular reptile species. Ageing is a complex phenomenon that can be described as the loss of vigor characterized by

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Vet Clin Exot Anim 13 (2010) 15–25
doi:10.1016/j.cvex.2009.09.003 vetexotic.theclinics.com
1094-9194/10/$ – see front matter

age-related increases in mortality, decreased reproduction, and general physical deterioration revealed in various pathologies.[6] Ageing in reptiles was previously reviewed in 1976[7] and later in 1994.[8,9] Little more data have come to light since. Three types of senescence are known to occur in reptiles.[8,9] Most squamates studied to date seem to undergo gradual senescence after maturity, similar to mammals and birds. In chelonians and crocodilians, growth continues throughout life and senescence is imperceptible or negligible. At the other end of the spectrum, rapid senescence and death following sexual maturity and mating, similar to that seen in salmon and small dasyurid marsupials, occurs in a few small reptiles and is best documented in Buettner's mabuya, *Mabuya* (*Trachylepis*) *buettneri*, a small African skink. Actual measurement of senescence can be achieved in several ways, and those methods are reviewed by Patnaik.[8] At the population level, an increase in the mortality rate would be expected with senescence, yet that is not always the case in reptiles studied to date.[8] At the individual level, experimental measurements of quantifiable age-related changes in metabolic function parameters, such as tissue glucose uptake, muscular glycolysis, tricarboxylic acid (TCA [Krebs]) cycle, cell membrane cholesterol/phospholipid ratio, hepatic antioxidant level, brain antioxidative enzymes, collagen cross-linkage, and enzyme thermolability, have been used to assess rates and patterns of senescence in various species of reptiles,[8] but such tests are not practical and are of little value in a clinical setting. This is unfortunate as reptiles are remarkable at concealing their age (**Fig. 1**). External features or lesions suggestive of old age in reptiles may be more a function of prior disease or trauma or may reflect inadequate or substandard husbandry (**Fig. 2**).

AGE ESTIMATION IN REPTILES

The determination of longevity and expected lifespan in a given species relies on data collected from specimens of known or estimated age. Techniques used in age determination of reptiles were reviewed by Castanet.[10] Prospective studies are lacking in cohorts of reptiles for which an accurate or close estimate of the hatching/birth date is known. Ironically, the long lifespan of many reptiles somewhat impedes or prohibits such studies. As juvenile captive-bred reptiles become increasingly popular in the pet trade, longevity in these species is likely to become better defined. However, owners or caregivers are typically unaware of the age of their pet reptile, and reptiles

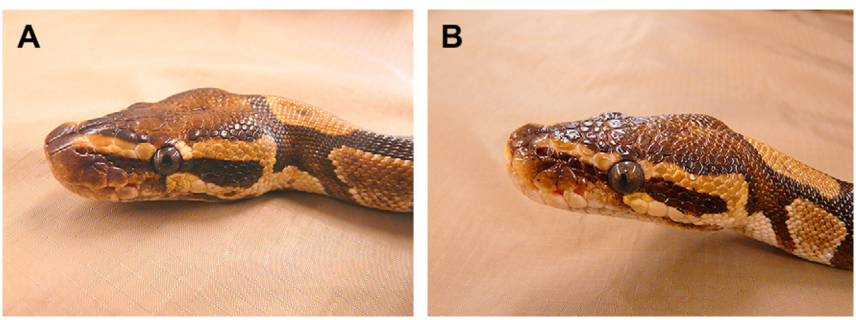

Fig. 1. Head of a 12-year-old (*A*) and a 40-year-old (*B*) ball python. The scales on the head of the older python are mildly raised and the epidermis between the scales is visible, imparting a slightly rougher outline to the skin; this could be an individual variation rather than one due to age. Estimating the age of a snake based on geriatric physical changes is difficult-to-impossible.

Fig. 2. Head of a 41-year-old Mexican beaded lizard (*Heloderma horridum horridum*). Bilateral idiopathic buphthalmia and slight bulging of the third eyelid has been present for over a decade, and has required periodic medical management.

show few, if any, outward signs of ageing. Although desirable, there is no useful noninvasive method for the clinician or caregiver to assess the age of a given individual reptile. Even size is not always reliable. Growth in most reptiles occurs throughout life[11] and although body size is positively correlated with age, even morphometric criteria or growth curves/charts established for wild individuals may be skewed in captivity as growth can be significantly affected by feeding regimen and husbandry. Deficiencies lead to stunting whereas overfeeding, or power-feeding, accelerates growth. Size can therefore be misleading, yet it may remain the best clue in younger animals of many species. Field biologists rely on the mark-release-recapture technique to assess longevity and other demographic patterns in wild reptiles.[11] Sclerochronology and skeletochronology refer to age estimation using natural growth marks in epidermal scutes and bone, respectively. The latter involves reading thin histologic bone sections and is more precise but clinically impractical because bones could hardly be harvested from the living pet; sclerochronology, or scute ring measurement, is less accurate and relies on growth cycles that may or may not be annual, especially for captive reptiles housed in an artificial, controlled environment (**Fig. 3**).[11] Furthermore, scutes in individual animals may be subject to uneven or excessive wear. Nevertheless, papers describing the use of sclerochronology in more than 20 chelonian species are listed in Castanet, 1994[11] and could be used to estimate the age of captive chelonians. Wilson and colleagues,[12] in 2003, provided a synopsis of the anatomy and physiology of growth ring deposition and critically reviewed prior sclerochronological studies in chelonians. Rattlesnakes (genera *Crotalus* and *Sistrurus*) add a segment to their rattle with each ecdysis so that a crude age may be estimated by counting segments, but shedding in snakes is irregular, may occur 2 to 3 times each year, and the rattle often breaks as it gains in length. Other methods of age assessment, such as measurement of telomere length in erythrocytes,[13] may show some potential in the future because it could be estimated from a simple blood sample.

LONGEVITY IN REPTILES

A geriatric reptile is one approaching the end of its lifespan. Owners often ask clinicians how long their pet will live. An awareness of the expected lifespan of a reptile

Fig. 3. Sclerochronology: Carapacial marginal scutes of a 14-year-old Home hingeback tortoise (*Kinixys homeana*). Annular growth rings are difficult to count.

species is therefore particularly useful in answering client concerns and in assisting the clinician to determine whether a patient may be considered geriatric. Distinct signs of ageing are rarely reported in wild reptiles. Although longevity is probably encoded in the genetic makeup of a species, a multitude of extrinsic factors, such as predation, pollution, nutrition, climate, disease, and even gender, come into play in determining how long an animal will live. Even within a species, longevity may differ with habitat across subpopulations.[14] Captive specimens are generally longer-lived than their wild counterparts, because captivity shields reptiles from adverse climatic pressures, starvation, and predation. However, captivity may also affect longevity negatively if husbandry parameters are inappropriate. Fast early growth, as is often promoted in captivity, has also been linked to impaired later performance and reduced longevity, possibly because an increased investment in growth would correspond to a decreased investment in prevention or repair of molecular damage that may compromise an animal later in life.[15] Even under proper housing and management, many wild-caught reptiles quickly die in captivity, whether from the stress imposed by capture and confinement or from an inability to adjust to a captive environment. Leaf-tailed geckos (*Uroplatus* spp), helmeted iguanas (*Corytophanes* spp), and most true chameleons (*Furcifer* and *Calumna* spp) are good examples of species that are notorious for doing poorly in captivity, yet are regularly sold in pet shops. Some reptile species, such as inland bearded dragons (*Pogona vitticeps*), veiled chameleons (*Chamaeleo calyptratus*), leopard geckos (*Eublepharis macularius*), crested geckos (*Rhacodactylus ciliatus*), ball pythons (*Python regius*), corn snakes (*Elaphe guttata*), or red-eared sliders (*Trachemys scripta elegans*) are now extensively and commercially raised, so that captive-bred specimens are readily available. As a rule, captive-bred animals are better acclimated to captivity and handling, are better feeders, and do not come with the heavy parasitic burden that wild-caught reptiles often bear. It would therefore seem logical that captive-bred reptiles, if at all available, would live longer in captivity than wild-caught animals of the same species. Under ideal captive conditions, longevity would exclude external factors and be determined by the rate of senescence.

Because many reptiles are long-lived and because of the aforementioned difficulties in determining the age of reptiles, there remain little longevity hard data on which to rely.[10,16,17] Existing data and anecdotal accounts of longevity records and clinical experience allow for a general sense of what may constitute old age in a given patient.

Obviously, longevity depends on the quality of the captive care provided. What follows focuses on captive animals, because longevity data for wild reptiles are even scarcer. Longevities provided are inferred from soft and hard data and are meant as rough guidelines.

Tuataras are long-lived reptiles, but captive specimens are only found in very few zoologic collections. One individual was documented to be 90 years old.[17] Life expectancy is thought to be between 60 and 100 years.[18]

Crocodilians are uncommon pets, yet American alligators (*Alligator mississippiensis*) and spectacled caimans (*Caiman crocodilus*) sometimes find their way into the pet trade. Alligators have been known to live to 73 years,[17] although 50 to 55 years may represent a reasonable lifespan.[10,16,17,19] Spectacled caimans may live 20 to 25 years.[16,17,19]

Turtles are much more commonly kept as pets. Most have a long lifespan if cared for properly. Gibbons[20] suggested that the protection provided by the shell of chelonians from predators and from the environment has allowed older individuals to reach their expected lifespan, hence weeding out deleterious mutations over time and positively affecting longevity in these animals. Red-eared sliders and box turtles (*Terrapene carolina* and *Terrapene ornata*) are regularly seen by reptile clinicians. Three European pond turtles (*Emys orbicularis*) are reportedly older than 60 years, with one of those estimated at 120 years old,[17] suggesting that other emydid turtles reach ages greater than 60. Even in a fairly small emydid, the spotted turtle (*Clemmys guttata*), longevity was estimated at 110 years for females and 65 years for males.[21] Red-eared sliders, usually captive or farm-raised, are often relinquished by owners as they outgrow their vivaria, but they can live past 40 years[17] and probably longer. A similar lifespan would be expected in other pond turtles, such as the painted turtle (*Chrysemys picta*), found across North America and often adopted from the wild. Three-toed box turtles (*Terrapene carolina triunguis*) easily live past 60 years,[22] and may live to be 100 years old. Some data suggest that the closely related ornate box turtle (*T ornata*) lives a shorter life, at least in the wild.[23] Snapping turtles (*Chelydra serpentina*) and softshell turtles (Trionychidae) may live 40 to 50 years in captivity.[17]

Testudinids, such as the desert tortoise (*Gopherus agassizii*), the African spurred tortoise (*Geochelone sulcata*), the leopard tortoise (*Geochelone pardalis*), the red-footed tortoise (*Geochelone carbonaria*), and the Russian tortoise (*Agrionemys horsfieldi*) are seen in the pet trade in North America, whereas Hermann's tortoise (*Testudo hermanni*) and the Greek, or spur-thighed, tortoise (*Testudo graeca*) are common pets in Europe. Desert tortoises, and probably other *Gopherus* species, may live up to 50 years in the wild[24] and much longer, even more than 100 years, in captivity (**Fig. 4**). Most *Geochelone* species live 50 years and more.[17] The giant *Geochelone*, the Aldabra (*Geochelone gigantea*) and the Galapagos (*Geochelone elephantopus*), deserve mention as they are arguably the longest-lived vertebrate species and live well over 100 years. One Aldabra at the Kolkata Zoo might have been 255 years old when it died in 2006. The *Testudo* species are also long-lived, and one spur-thighed tortoise lived to be 127 years old.[17]

Snakes and lizards live shorter lives. Common pet snake species include the boa constrictor or red-tailed boa (*Boa constrictor*), the ball python (*Python regius*), the Burmese python (*Python molurus bivittatus*), the corn snake (*Elaphe guttata*), kingsnakes and milksnakes (*Lampropeltis* spp), and garter snakes (*Thamnophis* spp). Boids probably live between 20 and 30 years on average[17] although one ball python lived to be 47 years old and 2 boa constrictors have lived to be 40 years old.[17] Corn snakes and kingsnakes are also expected to live 20 years and maybe up to 30 years, whereas the smaller colubrids, such as the garter snake, live between 10 and 15 years.[17]

Fig. 4. Head of a 100-years-old desert tortoise. There is slight hyperkeratosis over the scales of the head. (*Courtesy of* Jeri Oliphant, DVM, Arcata, CA).

Bearded dragons live 8 to 10 years,[17] possibly up to 14, and have a relatively short lifespan by reptilian standards. Other common captive agamids, such as the green water dragon (*Physignathus cocincinus*) and uromastyx lizards (*Uromastyx* spp) may live slightly longer. Green iguanas (*Iguana iguana*) typically live 10 to 15 years, but some have lived more than 20 years. Anoles (*Anolis* sp), commonly sold in pet shops, live 5 to 7 years. Leopard geckos have been known to live between 20 and 30 years, and that may be true of other eublepharine lizards, such as the African fat-tailed gecko (*Hemitheconyx caudicinctus*). A shorter lifespan of 10 to 15 years is reported for day geckos (*Phelsuma* spp) and New Caledonian crested geckos. Blue-tongued skinks (*Tiliqua scincoides*) and tegus (*Tupinambis* spp) have a life expectancy of 15 to 20 years. Life expectancy may be slightly less for savannah monitors (*Varanus exanthematicus*). Readers are referred to Slavens and Slavens,[17] 2009 for species not listed here. As more information becomes available and better care is provided to pet and captive reptiles, life expectancy may be extended.

CLINICAL CONSIDERATIONS

The authors propose that geriatric care of captive reptiles starts with the first consultation. Thorough questioning of the caregiver allows for a critical review of husbandry and provision of sound advice, which in turn, hopefully translates into an extended captive lifespan. Owners should be warned that reptiles are stoic animals and that they exhibit a very limited range of clinical signs. The onset of age-related ailments may be insidious and can be preceded by subtle decline in performance and vigor. In addition to monitoring appetite and fecal/urinary output, caregivers should be instructed to objectively and critically examine their animal regularly. A precision scale should be used to weigh their reptile weekly, or at least monthly, and weight entered into a log so that any trend might be detected. Weight loss, which can be gradual and easily go unnoticed, is often the first sign of a problem. Captive reptiles should ideally undergo a complete veterinary physical examination yearly. The oral cavity, nares, eyes, ears, integument, vent, feet and nails, and tail should be carefully inspected. Cardiac auscultation is typically unrewarding in reptiles, and palpation is limited in chelonians and somewhat restricted in many lizards and snakes, all reasons why ancillary tests are particularly useful in assessing health. Serial blood sampling and imaging, initiated at maturity or earlier, are undoubtedly the most powerful tools for

the diagnosis, monitoring, and management of geriatric issues. Although criteria for normality are fairly well established in cats and dogs, the same is not true for reptiles, which is why blood parameters and radiographs are best compared with blood results and radiographs taken earlier in life for each individual. In most reptile species, blood collection and radiographic imaging are fairly straightforward and do not require sedation or immobilization. Successive blood work and radiographs establish baselines for each individual reptile and can be repeated every second year, yearly, or even more often, as the patient ages. Serial blood work provides a better grasp of normal seasonal or physiologic fluctuation in blood parameter values in a given individual and allows the clinician to detect trends even when reference ranges for the species are unavailable (**Table 1**). Such trends may provide the clinician with grounds for focused individual geriatric care targeting a specific organ system and an objective means of assessing efficacy of therapeutic or supportive measures. Anemia, infection, parasitemia, hepatic and renal function, hypercholesterolemia, calcium homeostasis, and glycemia are among conditions for which blood parameters may change over the years. Yearly radiographs optimize the odds of detecting bone and soft tissue changes in an individual reptile (**Fig. 5**). Degenerative joint disease, spondylopathy, atherosclerosis, dystrophic mineralization, uroliths, cardiomegaly, hepatomegaly, renomegaly, coelomic masses, folliculogenesis, gravidity, pneumonia, and foreign bodies are among conditions that may be diagnosed radiographically. Most may

Table 1
Serial blood sample values of a female ornate Nile monitor lizard (*Varanus ornatus*) over the years. Individual variations in blood parameters are appreciable and allow for better interpretation of blood results should the animal become sick

Date	2001-07-01	2004-01-05	2006-01-06	2008-01-08
Hematology				
PCV (%)	37	32	21	27
RBC ($10^6/\mu L$)	0.7	1.0	0.8	0.8
Hb (g/L)	173	124	113	128
WBC ($10^3/\mu L$)	0.36	3.33	1.54	2.82
%Heterophils	79	50	34	47
%Lymphocytes	01	29	51	16
%Monocytes	—	6	—	3
%Azurophils	18	15	15	16
%Eosinophils	—	—	—	—
%Basophils	2	—	—	1
Chemistry				
Total protein (g/L)	36	68	47	51
Glucose (mmol/L)	2.2	8.8	5.4	3.5
Uric acid (μmol/L)	76	723	485	91
Calcium (mmol/L)	NA	10.72	2.81	8.67
Phosph (mmol/L)	NA	2.52	1.44	2.95
CK (IU/L)	NA	231	1286	1097
AST (IU/L)	NA	14	30	19

Abbreviations: AST, aspartate aminotransferase; CK, creatine kinase; Hb, hemoglohin; PCV, packed cell volume; Phosph, phosphorus; RBC, red blood cell; WBC, white blood cell.

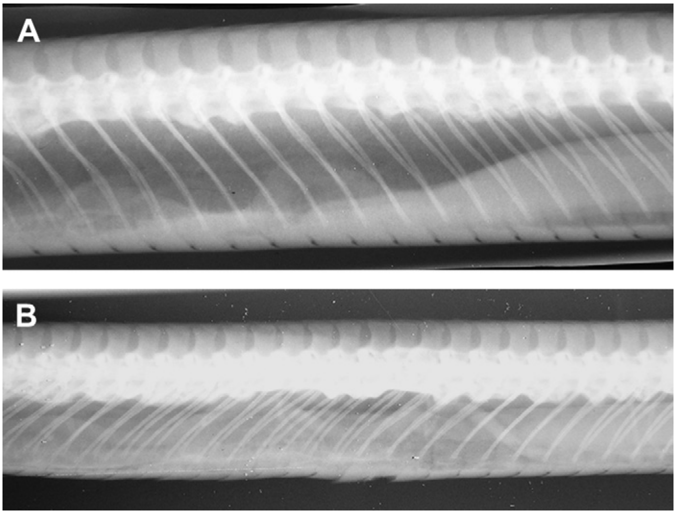

Fig. 5. Lateral plain radiographic view of the caudal lung field of a male tiger rat snake (*Spilotes pullatus*) at age 5 (*A*) and 6 (*B*) years. Hyperostotic spondylopathy is slightly more pronounced and the aorta is more radiodense at age 6 years.

easily be subclinical and not be identified on physical examination. As in most vertebrate species, neoplasia in all organ systems is seen with increased frequency in older reptiles. When diagnosed early, some of these conditions may be addressed therapeutically or may be decelerated by means of dietary or husbandry recommendations, increasing the life expectancy of the patient. Additional diagnostic modalities, such as magnetic resonance imaging, bone scans, and endoscopy require immobilization and are now available to further define lesions or assess progression of disease in the older patient. Anesthesia in older reptiles, as in other geriatric vertebrates, might come with an increased risk of complications. The newer volatile anesthetics combined with short-acting or reversible drug combinations probably offer the widest safety margins. Tracheal intubation, placement of an intravenous or intraosseous access line, and the use of monitoring devices will help detect a complication and allow for early intervention. With careful planning, the need for anesthesia should not deter the clinician, owner, or caregiver from pursuing advanced diagnostics for captive reptiles.

The following list is by no means exhaustive, but includes the most common conditions associated with ageing in reptiles.

Integument

Skin lesions are most easily noticed by caregivers. Scars are common in older reptiles. Skin tone and gloss may or may not be decreased. Ecdysis may be less frequent in older squamates but may also be more frequent with age or disease. Hyperkeratosis, cutaneous growths and excrescences, broken tails and regrowths, missing toes and/or nails, and overgrown beaks are more common in aged animals.

Digestive System

Anorexia is probably the most common clinical sign displayed by sick or geriatric reptiles, but is very nonspecific. Periodontal disease is seen in older lizards, especially in acrodont species (eg, Agamidae, Chamaeleonidae). Delayed gastrointestinal transit

and constipation are common presenting complaints in older squamates. Diarrhea is fairly rare, but constipation is common and may be caused by renomegaly in lizards.

Skeletomuscular System

Muscle wasting and degenerative bone and articular changes may be seen in older reptiles, and squamates in particular. Spondylopathies are particularly prevalent in iguanas and ophidians. Body muscle tone may be reduced in geriatric snakes, so that they coil more loosely around the arm/hand. Arthritic animals may benefit from rearrangement of the enclosure/cage furniture, weight management, and judicious use of nonsteroidal anti-inflammatory drugs.

The respiratory system is affected fairly rarely in older reptiles. Tachypnea, bradypnea, and dyspnea may indicate pulmonary disease or may reflect pain or metabolic disturbances. Open-mouthed breathing is typically associated with serious tracheal or lung pathology.

Cardiovascular System

Atherosclerosis and dystrophic myocardial mineralization are common in older snakes and lizards. Death may be peracute when an affected artery ruptures. Luminal narrowing of aortic arches, carotids, and cerebral vessels may lead to more subtle and progressive signs, neurologic or other. Hypercholesteremia is often seen, and the causes are poorly understood. The use of cholesterol-lowering drugs in such animals remains unexplored.

Urinary System

Chronic, progressive renal disease is fairly common in older squamates. In many lizards, nephrosis and renal swelling may impinge on the colon at the pelvic inlet, which commonly results in constipation, particularly in green iguanas. Secondary renal hyperparathyroidism is sometimes seen, as serum calcium levels drop and phosphorus levels rise. Articular gout causes painful swelling of the limbs. Visceral gout, insidious and difficult to diagnose, may cause death with no premonitory signs or may cause various degrees of lethargy, anorexia, and other nonspecific signs. The efficacy and safety of allopurinol, colchicine, and other drugs targeting the uric acid pathway are largely unknown. Fluid therapy and diuresis, dietary adjustments, and pain management are more likely to help hyperuricemic reptiles. Renal neoplasia occurs in all reptiles, but seems unusually prevalent in older kingsnakes and milksnakes (*Lampropeltis* spp).

Reproductive System

Reptiles typically remain reproductively active throughout their life. Reproductive senility, as measured by decreased reproductive output, occurs in most vertebrates but is poorly documented in reptiles. Although a reproductive decline with old age has been documented in some crocodilians, oogonial proliferation is known to persist late into adulthood of at least some alligators (*A mississippiensis*) and clutch size seems to increase with age in some snakes, lizards, and turtles.[8] Older female reptiles may be more at risk of follicular stasis or dystocia, because they may be obese or more likely to be struggling with calcium homeostasis. Yolk coelomitis and ovarian neoplasia sometimes occur. Infection or impaction of the hemipenal pockets in lizards and snakes tend to be seen more often in older individuals.

Nervous System

Neurologic signs in reptiles include incoordination or ataxia, opisthotonos or stargazing, loss of righting reflex, tremors, and seizures. Tremors and fasciculations in old reptiles are almost always related to hypocalcemia and are not truly neurologic. Brain and spinal cord tumors are rare, but neurologic signs are seen with cerebral xanthomas or cholesterol granulomas in geckos, green water dragons, and possibly other squamates.

Endocrine System

There are very few documented cases of endocrinopathies in reptiles. Hypothyroidism has been reported in chelonians and lizards and anecdotally linked with overfeeding of crucifers or other goitrogenic food items.

Immune System

Older animals may be more susceptible to infectious diseases, although there is little evidence to support such an assertion. In the giant tortoises, thymic hyperplasia sometimes manifests as a discrete mass at the ventral aspect of the base of the neck and may be mistaken for thyroid goiter. Thymomas are sometimes seen in older snakes, especially boa constrictors. Lymphoproliferative disorders are fairly common, especially in chelonians and snakes, and they cause clinical signs that may be very slow to progress and that vary according to the affected organ systems.

Special Senses

Lipid keratopathy, or corneal lipidosis, occurs in some agamids and iguanids and has been seen regularly in older green water dragons and plumed basilisks (*Basiliscus plumifrons*) at the Toronto Zoo. Cataracts are not uncommon in older reptiles. Age-related changes in hearing and olfactive acuity in reptiles have not been documented.

Practically all the conditions discussed are more likely to be detected early if a captive reptile is examined regularly and is followed closely by means of blood work and radiographs taken serially over the animal's life. Such assessments assist in making decisions for treatment of the individual and also allow for data to be accumulated and shared with the herpetological community, who can gradually refine their approach to diseases and care of old reptiles. Although old age cannot be cured, diagnosing age-related pathologies allows the clinician to suggest treatments and alternative husbandry methods that may improve the quality of life for aged reptiles. Older reptiles may require daily assistance to ensure adequate hydration, thermoregulation, and nutrition as they face the challenges of old age. Further, veterinary assessment combined with observations by the caregiver or owner also guides decisions about when declining quality of life may dictate euthanasia. Even if they hardly show their age, geriatric reptiles surely deserve the same attention as other geriatric animals.

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